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Universities and Knowledge-Intensive Business Services (KIBS) as Sources of Knowledge for Innovative Firms in Peripheral Regions

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Universities and Knowledge-Intensive Business Services (KIBS) as Sources of Knowledge for Innovative Firms in Peripheral Regions

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PINTO H., FERNANDEZ-ESQUINAS M. and UYARRA E. Universities and knowledge-intensive business services (KIBS) as sources of knowledge for innovative firms in peripheral regions, *Regional Studies*. Knowledge-intensive business services (KIBS) make a crucial contribution to regional innovation. Their relevance is potentially higher in peripheral territories, assisting small and medium-sized enterprises to access knowledge. Nevertheless, regions often concentrate research and development capabilities in the public sector, while highly specialized services provided by firms are scarce. Using data from 737 firms in Andalusia, Spain, this article connects the literatures of KIBS and university–industry interactions. This paper finds that absorptive capacity remains a central dimension in interactions with universities and the use of KIBS. Even if KIBS firms do not demonstrate higher propensities to interact with universities, the use of both channels is evidence of knowledge circulation between innovative firms and universities' advanced services.

Knowledge-intensive business services (KIBS)   University   University–industry interactions   Regional development
Peripheral regions   Regional innovation policy

PINTO H., FERNANDEZ-ESQUINAS M. and UYARRA E. 大学与知识密集型服务业（KIBS）做为边陲区域创新企业的知识来源，*区域研究*。知识密集型服务业（KIBS）对于区域创新有着关键性的贡献。而两者在边陲地区可能有更高的相关性，进而协助中小型企业取得知识。但区域经常将研究与发展能力集中于公部门，而由企业所提供的专业化服务则非常稀少。本文运用西班牙安塔露西亚的 737 个企业资料，连结知识密集型服务业与大学—产业互动的文献。吸收能力仍然是与大学互动和运用知识密集型服务业的核心面向。虽然知识密集型服务业的企业并未展现出更倾向与大学互动，但此二管道的运用仍显示，创新企业与大学的进阶服务之间存在着知识流通。

知识密集型服务业（KIBS）　大学　大学—产业互动　区域发展　边陲区域　区域创新政策

PINTO H., FERNANDEZ-ESQUINAS M. et UYARRA E. Les universités et les services aux entreprises à forte intensité de connaissances (KIBS) comme sources de connaissances pour les entreprises innovatrices situées dans les zones périphériques, *Regional Studies*. Les KIBS (knowledge-intensive business services; les services aux entreprises à forte intensité de connaissances) apportent une contribution primordiale à l'innovation régionale. En principe, leur importance est plus grande dans les territoires périphériques, aidant les petites et moyennes entreprises à avoir accès aux connaissances. Néanmoins, la capacité de recherche et de développement des régions se concentre souvent sur le secteur public, alors que rares sont les services très specialisés fournis par les entreprises. Employant des données auprès de 737 entreprises situées en Andalousie (Espagne), cet article associe la documentation au sujet des KIBS aux interactions entre les universités et l'industrie. La capacité d'absorption reste une dimension essentielle des interactions entre les universités et l'emploi des KIBS. Même si les entreprises KIBS ne démontrent pas de propensions plus élevées à interagir avec les universités, l'emploi des deux voies laissent supposer la circulation des connaissances entre les entreprises innovatrices et les services avancés des universités.

Services aux entreprises à forte intensité de connaissances (KIBS)   Université   Interactions entre l'université et l'industrie
Aménagement du territoire   Régions périphériques   Politique régionale en faveur de l'innovation

PINTO H., FERNANDEZ-ESQUINAS M. und UYARRA E. Hochschulen und wissensintensive Geschäftsdienste als Quellen des Wissens für innovative Firmen in Randgebieten, *Regional Studies*. Wissensintensive Geschäftsdienste leisten einen entscheidenden Beitrag zur regionalen Innovation. In Randgebieten ist ihre Relevanz potenziell noch höher, da sie kleinen und mittelständischen Unternehmen Zugang zu Wissen verschaffen. Dennoch konzentriert sich das Potenzial für Forschung und Entwicklung in vielen Regionen auf den öffentlichen Sektor, während hochspezialisierte Dienstleistungen von Firmen selten sind. Anhand der Daten von 737 Firmen in Andalusien (Spanien) wird in diesem Artikel die Literatur über wissensintensive Geschäftsdienste mit Literatur über die Zusammenarbeit zwischen Hochschulen und Industrie verknüpft. Im Bereich der Zusammenarbeit zwischen Hochschulen und der Nutzung von wissensintensiven Geschäftsdiensten stellt die absorptive Kapazität weiterhin eine zentrale Dimension dar. Selbst wenn Firmen für wissensintensive Geschäftsdienste keine erhöhte Neigung zur Zusammenarbeit mit Hochschulen zeigen, lässt die Nutzung beider Kanäle doch auf einen Wissenskreislauf zwischen innovativen Firmen und den erweiterten Diensten von Hochschulen schließen.

Wissensintensive Geschäftsdienste Hochschulen Zusammenarbeit zwischen Hochschulen und Industrie Regionalentwicklung Randgebiete Regionale Innovationspolitik

PINTO H., FERNANDEZ-ESQUINAS M. y UYARRA E. Universidades y servicios a empresas intensivos en conocimiento (SEIC) como fuentes de conocimiento para empresas innovadoras en regiones periféricas, *Regional Studies*. Los servicios a empresas intensivos en conocimiento (SEIC) contribuyen de manera fundamental a la innovación regional. Su relevancia es potencialmente más importante en los territorios periféricos porque permiten que las pequeñas y medianas empresas puedan acceder al conocimiento. Sin embargo, con frecuencia las capacidades de investigación y desarrollo en las regiones están concentradas en el sector público, mientras que escasean los servicios altamente especializados ofrecidos por empresas. A partir de los datos de 737 empresas andaluzas, en este artículo creamos un vínculo entre las bibliografías de los SEIC y de las interacciones entre las universidades y la industria. La capacidad de absorción sigue siendo un elemento central de las interacciones con las universidades y el uso de los SEIC. Aunque las empresas para SEIC no demuestran una predisposición elevada de interactuar con las universidades, el uso de ambos canales sugiere la circulación de conocimiento entre empresas innovadoras y los servicios avanzados de las universidades.

Servicios a empresas intensivos en conocimiento (SEIC) Universidad Interacciones entre universidades y la industria Desarrollo regional Regiones periféricas Política de innovación regional

JEL classifications: C51, O30, O32, R58

INTRODUCTION

Knowledge-intensive business services (KIBS) are increasingly considered to be key for regional development. They are placed at the centre of innovation systems because of the role they play as carriers, diffusers and co-creators of knowledge that can confer competitive advantages for client firms (MILES *et al.*, 1995; DEN HERTOG, 2000; CAMACHO and RODRÍGUEZ, 2005; MULLER and ZENKER, 2001; MULLER and DOLOREUX, 2009). The literature also underlines the importance of KIBS as key components of local innovation systems (COOKE and LEYDESDORFF, 2006), often acting as knowledge mediators (ASLESEN and ISAKSEN, 2010). The provision of KIBS can be especially important in peripheral regions since they may not only assist local small and medium-sized enterprises (SMEs) in their search for solutions to complex problems, but also connect them with knowledge available in other places. These services may also help up-skill the regional workforce more effectively than formal training and education.

Empirical research shows that KIBS – especially those with high levels of scientific and technological knowledge – usually cluster in large metropolitan areas. In peripheral economies, specialist knowledge may instead be concentrated in universities and public research organizations (PROs), rendering these actors proximate and more affordable providers of advanced services to regional companies. Thus, in peripheral regions, universities may be used by innovative firms as pivotal sources of knowledge-intensive services complementing KIBS firms or compensating for their relative absence.

The role of KIBS as sources of knowledge for innovation and the question of university–industry interactions are rarely connected, however. To address this gap, this article integrates both streams of research to examine the uses made by firms of advanced business services and knowledge from universities within a regional innovation system. The main goal is to investigate the role of KIBS and universities as knowledge providers for innovative firms in a peripheral region. More specifically, the research questions are:

- What are the factors that influence the use firms make of universities and/or KIBS?
- What are the differences, if any, between firms that use universities and those that use KIBS as sources of knowledge?
- Does geographical proximity influence knowledge circulation from KIBS or universities?

The paper thus focuses on the use, rather than on the provision (or supply), of knowledge-intensive services for innovation in a peripheral region, with special attention paid to three kinds of connections: between firms and universities, between firms and KIBS, and between KIBS and universities. For that purpose, the analysis uses as its empirical base a survey of 737 innovative firms in Andalusia (Spain) to observe how structural characteristics of the firms, absorptive capacity and proximity influence different forms of interactions with universities and KIBS firms.

The paper is organized as follows. The background section reviews the presence of KIBS in peripheral regions and the role of university–industry interactions. The following section describes the context of the region of Andalusia, Spain. The methodology presents the characteristics of the survey, followed by the descriptive results of the measures of university–firm interactions and the use of KIBS. The analysis section includes the strategy for building independent and dependent variables, the econometric estimation and results. The paper concludes with the main findings and policy implications.

BACKGROUND

KIBS and innovation

A large body of scholarly research has in the last decade stressed the importance of external sourcing of knowledge for innovation in firms. As a result of the increasing cost, complexity and interconnectedness of innovation, 'open innovation' strategies and innovation networks have been identified as key determinants of innovation performance (Chesbrough, 2003). Firms, particularly SMEs, may be able to overcome their resource constraints and lack of 'absorptive capacity' through engaging in innovation-related cooperation with various external partners.

The use that firms make of university research has been discussed at length in the literature (for a recent review, see Perkmann *et al.*, 2013). Empirical studies on the use of universities by firms have, for instance, dealt with the factors determining academic and firm engagement, the multiple modes of knowledge exchange, and the importance of proximity in influencing such interactions. Nonetheless, universities are only one possible source of knowledge with other sources acting as complements, or substitutes (Tether and Tajar, 2008).

In particular, the role of KIBS as a key source of knowledge for innovation has been increasingly recognized. KIBS are traditionally defined as 'services that involve economic activities which are intended to result in the creation, accumulation or dissemination of knowledge' (Miles *et al.*, 1995, p. 18). Miles *et al.* (1995) further distinguish between 'traditional professional services' (P-KIBS) and 'new technology-based services' (T-KIBS). P-KIBS include services such as legal and accounting activities, as well as business and management services, market research, etc., while T-KIBS mainly relate to information and communication technologies (ICTs) as well as other technical activities (e.g., information technology-related services, engineering, research and development (R&D) consulting, etc.). Other contributions have stressed, however, that important differences exist within these categories (von Nordenflycht, 2010; Malhotra and Morris, 2009; Consoli and Elche-Hortelano, 2010). Using official data on occupational information in the United States, Consoli and Elche-Hortelano (2010), for instance, observe a great deal of diversity in the occupational structures and skill requirements across KIBS sectors.

KIBS are deemed crucial for the creation and commercialization of new products, services and processes. Kuusisto and Meyer (2003, p. 1) further note that KIBS 'are vital carriers, shapers and creators of innovations, whether they are technological or managerial in nature'. As carriers of innovation, they play an important intermediating role in that they 'help or assist in transferring knowledge within, and across, organizations, industries and clusters' (Shearmur and Doloreux, 2009, p. 82).[1] Freel (2010), using data on firms in Northern England, found that the contribution of KIBS to innovation processes may be particularly important for larger firms and younger firms, as well as for service firms and technology-based service firms (see also García-Quevedo and Mas-Verdú, 2008). Collaboration with KIBS equally tends to be stronger for firms undertaking R&D and for those involved in novel innovation activities. Finally, KIBS have been found crucially to assist innovative SMEs with the provision of specialist knowledge and informational resources needed to improve their 'absorptive capacity'. Muller and Zenker (2001), for instance, found that SMEs interacting with KIBS were more likely to introduce innovations, invest in R&D and cooperate with the wider technological infrastructure.

KIBS and regional development

KIBS have also been described in the literature as important contributors to innovation at the regional level (Muller and Zenker, 2001). They are regarded as a key component of local innovation infrastructure (Cooke and Leydesdorff, 2006), as key knowledge intermediaries that facilitate collaboration between actors in regional innovation systems (Aslesen and Isaksen, 2010), and as important contributors to the modern development of cities (Simmie and Strambach, 2006).

KIBS firms tend to concentrate in large metropolitan areas (Wood *et al.*, 1993; Simmie and Strambach, 2006; Aslesen and Jakobsen, 2007; Chadwick and Glasson, 2008), characterized by high densities of innovative industries, access to knowledge spillovers arising from proximity to related activities, communications infrastructure, high-quality labour markets, and greater opportunities for face-to-face interaction. KIBS are absorbers of information and skills and thus 'their location will need to provide them with access to these' (SHEARMUR, 2010, p. 45). Location and proximity are also important in the delivery of knowledge-intensive services, which tend to be delivered in close contact with the client (or 'co-produced').

Peripheral areas, on the other hand, are afflicted by a relative lack of support infrastructure, social capital, access to markets and skilled human resources (SHEARMUR and DOLOREUX, 2009; TÖDTLING and TRIPPL, 2005) and tend to present a lower concentration of KIBS. SMEs in those areas may therefore find access to specialist knowledge provision problematic. ASLESEN and ISAKSEN (2010) indeed found that peripheral regions in Norway have a lower presence of KIBS. Interestingly, KIBS in those regions also had a higher average R&D, more local knowledge exchange and more formal collaboration with the regional knowledge infrastructure compared with those in more central regions. They concluded that in peripheral regions KIBS firms play an important mediating role between the analytic knowledge held internally and the synthetic knowledge basis of their (mainly) local clients (ASLESEN and ISAKSEN, 2010, p. 118).

Differences also exist across different KIBS types. SHEARMUR (2010), for instance, found that in Canada T-KIBS locate in larger and more central cities and collaborate with all types of outside actors, including public institutions, while also engaging in local collaborations. P-KIBS are, by contrast, more reliant on local markets. According to TETHER and TAJAR (2008) T-KIBS have stronger links with the public science base. By using universities for accessing and recombining knowledge and adapting it to the demands and the productive problems of their clients, T-KIBS can act as effective intermediaries or brokers between academic knowledge and the wider economy. However, T-KIBS may interact less frequently or less intensely with local universities when the public research system is detached from the industrial sectors that demand knowledge-intensive services.

Universities and KIBS as specialist knowledge providers

Empirical studies suggest that KIBS act as knowledge intermediaries and as complementary sources of knowledge vis-à-vis other knowledge providers. For instance, TETHER and TAJAR (2008) argue that KIBS firms provide a 'second knowledge infrastructure', with universities and other PROs acting as the 'first knowledge infrastructure'. Yet, as noted by Tether and Tajar, analyses of university–industry collaboration rarely connect the use that firms make of related sources of knowledge, including KIBS. Using data from the UK Community Innovation Survey, they found that KIBS complement rather than substitute other external sources of knowledge. LAURSEN and SALTER (2004) also found that firms that have an 'open' strategy in relation to their use of external sources of knowledge are likely to collaborate with a multitude of partners including universities.

What can be said, then, about the use of knowledge-intensive services in peripheral regions? Given the 'KIBS-poor' landscape of many peripheral regions, universities and PROs may prove to be closer and more affordable providers of specialist knowledge for regional companies. Numerous studies have indeed shown that universities in peripheral regions are important players in entrepreneurship, rural development, provision of technical infrastructure and connectivity (e.g., ORGANISATION FOR ECONOMIC CO-OPERATION AND DEVELOPMENT (OECD), 2010). Accordingly, some regional governments may even try to use universities and PROs to correct this 'market failure', at least as far as technical services are concerned. This view resonates with the broader notion of knowledge-intensive service activities (KISA)[2] (OECD, 2006; MARTÍNEZ-FERNANDEZ *et al.*, 2011), which explicitly recognizes that different types of organizations are involved in the delivery and consumption of knowledge-intensive activities.

However, when considering the complementarity (or lack thereof) of universities and other sources of specialist knowledge, it is also necessary to take into account the diversity of specialist knowledge services and the multiplicity of channels through which universities and firms interact. It could be argued that some channels are more likely to be complementary vis-à-vis different types of KIBS, whereas others are more likely to act as substitutes.

Thus, certain types of university–industry links may be akin to KIBS provision, the relevance of which is likely to be significant in peripheral regions. The literature has examined in detail the multiplicity of channels through which firms interact with universities. Studies such as that by COHEN *et al.* (2002) found that open channels, such as publications, conferences, informal links and consultancy activities, were the most important for firms. SCHARTINGER *et al.* (2002) showed that the main channel for knowledge transfer was the mobility of human capital, including the co-supervision of doctorates or directly through employment. A lot of policy attention has been given to intellectual property-related interactions, although there is a consensus in the literature that such interactions play a relatively small role (COHEN *et al.*, 2002; AGRAWAL and HENDERSON, 2002). Finally, various forms of academic consulting may play an important role, although this form of engagement remains understudied (PERKMANN and WALSH, 2008; RENTOCCHINI *et al.*, 2013). The characteristics of such links are similar to those interactive exchanges addressed in the KIBS literature, including those of specialized technical services, consultancy and some forms of training.[3] Different types of firms would use different channels to a different extent (MEYER-KRAHMER and SCHMOCH, 1998; COHEN *et al.*, 2002). For instance intellectual property-related links are more important in the pharmaceutical and biotechnology industries than in other sectors (MANSFIELD, 1995). According to SCHARTINGER *et al.* (2002), low- and medium-technology manufacturing firms are likely to look for technical services such as analysis, calibrations and technical accreditations, or they may use university consulting to gain access to expertise they lack.

It can be therefore assumed that manufacturing firms in low- and medium-technology sectors use universities as support service suppliers, mostly for technical services and training but not so much for collaborative R&D and knowledge commercialization. Small firms may demand more routine, problem-solving services and consultancy, which are more likely to be available from local institutions (SIEGEL *et al.*, 2007). It may therefore be expected that in regions with a lower presence of large firms and technology-intensive sectors, university–industry interactions are predominantly likely to adopt the form of KIBS.

Role of geographical proximity in influencing interactions

Finally, some knowledge interactions may be more local than others. Scholars have long sought to understand the influence of geographical proximity on the university–industry knowledge interaction (e.g., D'ESTE and IAMMARINO, 2010; LAURSEN *et al.*, 2011). While some studies have found evidence of physical proximity facilitating interaction between industry and academia, others have reported mixed results, and generally concluded that spatial proximity, while important, may be secondary compared with other factors such as the scientific excellence of university departments (LAURSEN *et al.*, 2011). The same questions have been addressed in studies of KIBS–client relations, which highlight the importance of proximity in the provision of KIBS (KOCH and STAHLECKER, 2006; ASLESEN and JAKOBSEN, 2007). Proximity may therefore be particularly relevant for KIBS-type relationships that firms have with universities.

D'ESTE and IAMMARINO (2010) found that for some relationships such as joint research collaboration geographical proximity is important, while others, such as consultancy or short-term contracts, can be managed at arm's length. They conclude, however, that the spatial dimension of university–industry relations is far from simple and uniform (see also LAURSEN *et al.*, 2011). Instead, 'a complex set of overlapping factors – most of them embedded in the industrial and scientific structure of regional systems – underlie the relevance of geographical proximity and the actual potential for localised knowledge spillovers' (D'ESTE and IAMMARINO, 2010, p. 348; see also UYARRA, 2010). All this evidence suggests a need to observe the specific dynamics of firms and universities in any regional system to develop an understanding of how universities may be used as KIBS providers.[4]

To conclude, it can be assumed that firms use different external sources of knowledge depending on their organizational and human resources capacities, their needs for the productive processes, their location and opportunities found in their environment. Firms may use university services and KIBS as distinctive and complementary channels, but also as substitutes when they find strategic advantages, difficulties or a situation of market failure. In regions with a lower presence of service firms and technology-intensive sectors, university–industry interactions may predominantly adopt the form of KIBS, although some firms may interact with both sectors and act as intermediaries and carriers of knowledge. The regional context of this study together with the methodology developed for observing external sources of knowledge of firms are used for informing the discussion about the types of services and university channels used by local firms, and for explaining how firm interaction with both KIBS and universities is more likely to introduce innovation.

THE REGIONAL CONTEXT

This study focuses on the region of Andalusia. Located in the south of both Spain and Europe, the region has almost 9 million inhabitants and covers an area of 87 000 km^2. It is geographically diverse with large rural enclaves and several metropolitan areas. A traditionally less developed region, Andalusia has undergone a rapid process of change catching up with European standards. Nonetheless, in the early 21st century the region differs from others in Spain in terms of its lower competitiveness (73.5% of the per capita gross domestic product (GDP) of Spain) (CONSEJO ECONÓMICO Y SOCIAL DE ANDALUCÍA (CES), 2011). Since 2008 the economic crisis has had a significant impact, resulting in firm destruction and increased unemployment, mainly in traditional industrial sectors and among SMEs (CES, 2011).

Andalusia is a peripheral innovation system because of a lack of industrial agglomeration and innovative firms. Investment in R&D is low by advanced economy standards (1.5% of GDP). Only 33% of R&D expenditure of the region is incurred by businesses (INSTITUTO NACIONAL DE ESTADÍSTICA (INE), 2010). A particular feature of the business community is that family-owned SMEs account for a large proportion of the manufacturing and service sectors. This indicates that important sectors are directed towards local markets and based on low- and medium-technology activities and services.

The region does contain emerging-technology industries, especially those in the energy, aeronautics and agro-food sectors, and has increasingly active innovation policies in place (OECD, 2011), which give KIBS an important significance. An important part of the economy is concentrated in the service sector,

Table 1. Activity sector of firms in Andalusia and Spain

	Andalusia		Spain	
	Number of firms	%	Number of firms	%
Total number of firms	492 341	15.10	3 250 576	100
High-technology manufacturing	944	0.19	7956	0.24
Medium-technology manufacturing	2248	0.46	19 935	0
Low-technology manufacturing	24 562	4.99	173 339	5.33
Mining and extractive industries	471	0.10	2743	0.08
Energy and water	2441	0.50	17 739	0.55
Construction	49 608	10.08	394 385	12.13
Technology KIBS	6442	1.31	59 723	1.84
Professional KIBS	53 647	10.90	370 668	11.40
Commerce and other services	351 978	71.49	2 204 088	67.81

Note: KIBS, knowledge-intensive business services.
Source: Instituto Nacional de Estadística (INE), General Directory of Enterprises, 2010.

with an added value of 65% of GDP in 2010, while manufacturing is 12.7%, construction is 10.7% and agriculture is 5.8% (CES, 2011). The industrial structure of Andalusia is thus formed overwhelmingly of service firms, which make up 83% of all firms (Table 1). Nevertheless, few service firms are knowledge intensive. Firms in the region concentrate mainly on the tourist sector, commerce and personal services. Only 12% of service firms are included in some of the KIBS categories. Among these, 1.24% are in technical services. This context highlights the scarcity of some kinds of KIBS firms, especially high-technology services, engineering consultancy and P-KIBS that provide services for technical accreditations and testing.

Several studies have showed the dynamics and distribution of KIBS firms in Spanish regions situating Andalusia as a peripheral region when compared with other 'core' regions. The geography of KIBS in Spain shows a concentration in metropolitan areas, particularly Madrid, where 23% of the firms are KIBS, followed by Catalonia (19%) and the Basque Country and Navarra (17%) (Camacho and Rodríguez, 2005). The dominance of Madrid is overwhelming in the case of bigger firms: it concentrates 49% of all KIBS firms in the country with over 200 employees (Vence and González, 2009). Andalusia is in relative terms in a similar position to the rest of the regions: for all of them the percentage of firms in this sector is between 9% and 13%.

The differences between regions in terms of supply and demand are also important. Over 40% of the turnover of KIBS firms located in Madrid is with clients outside of the region, while in Catalonia and the Basque Country the share of extra-regional activity of KIBS is 25%. In Andalusia this proportion is around 6%, a similar figure to other regions (Vence and González, 2009). Conversely, the demand for KIBS in Andalusia is much bigger than the internal supply (33% of the services are provided internally). This reinforces the hypothesis of agglomeration and suggests a market dominance of KIBS located in highly populated central urban areas (Torrecillas and Fisher, 2011).

This backdrop has implications for regional development, given the importance of KIBS in terms of technological dynamics for medium- and high-technology sectors. It also suggests an absence of specialized service firms which gives the public research system an important role in peripheral regions such as Andalusia, especially higher education institutions.

The higher education and research system in Andalusia comprises nine public universities with some 250 000 students and 17 000 teaching and research staff, as well as several PROs.[5] The regional government controls the funding and management of the higher education sector. The growth of the university system during the 1980s and 1990s led to a high concentration of R&D resources in universities, which account for 45% of R&D expenditure and 61% of researchers in the region (INE, 2010).

Recent innovation policies in Andalusia have sought to boost innovation in the private sector via economic incentives and a network of interface organizations to link firms with universities, in addition to the technology transfer offices created by the universities and PROs (Consejería de Innovación Ciencia y Empresa (CICE), 2006). In particular, the regional innovation policy has created an extensive network of innovation support offices, the main example being the so-called RETA (Red de Espacios Tecnológicos de Andalucía – Andalusian Technology Network), with over 25 offices located in cities and rural areas (OECD, 2011). An important role of this network is to connect firms to university research teams and other PROs. They seek out research partners for the various services provided by universities, not only for collaboration. Sometimes they look for research teams to help firms apply for innovation projects, and other times they facilitate personal relationships for local firms looking for university experts. In addition, the regional programme for creating spin-offs and start-ups has resulted mostly in service firms (IESA, 2010).

The regional innovation policies thus try to promote outreach functions of universities and other public centres. Given the low presence of domestic KIBS firms relative to core regions and the important size and presence of universities, higher education institutions have a special role as both 'KIBS providers' and 'KIBS facilitators'.

METHODOLOGY

Data sources, survey and fieldwork

The empirical strategy is to observe several flows in the knowledge circulation model of the regional innovation system, with special attention to three kinds of connections: between firms and universities, between firms and KIBS, and between KIBS and universities. For that purpose a survey of firms was carried out (IESA, 2009). The data source for the survey is a registry of 1980 innovative firms in the region collected by the network of offices of the regional government (RETA and CITANDALUCÍA) that provide innovation services to businesses. The firms in the registry are those that have received some kind of public aid and consulting support related to innovation, together with the firms classified as potentially innovative by this network. This population of firms does not represent the whole industrial fabric of the region, but only the firms with a more innovative profile. Nevertheless, this registry includes a variety of firms in terms of sectors and size, both SMEs and larger firms. It is more up to date than the registries for official innovation surveys, provides a better coverage of SMEs, and the identification of firms is more accessible. From the above source a stratified sample of 800 firms was designed and categorized according to province and population size of the location. Firms selected were contacted by post and telephone; an appointment was then made with a member of the management team; and interviews at the firm premises were carried out using professionally qualified interviewers. The response rate was 73% in the first phase of fieldwork. The same procedure was used for a second phase of fieldwork in order to obtain the designed sample. The substitute sample for replacing non-respondents had a response rate of 76%. The total sample at the end of data collection was 737 firms.[6] These were small, medium-sized and large companies in a variety of sectors, reflecting the diversity of the innovation profiles of industry in the region of study (see Table A1 in Appendix A). This sample includes a group of firms that are KIBS themselves (21% of firms is classified as T-KIBS and 14% as P-KIBS). This proportion is high compared with the general distribution of firms in the region.

Questions set and descriptive results for university-firm interactions and use of KIBS

The survey included a set of questions reflecting multiple forms of interactions with universities. Twelve possible types of interaction were selected (Table 2). For each type of interaction firms were asked if they had had this relationship in the previous five years and how many times. This formulation was aimed at obtaining a detailed descriptive measurement of the 'diversity' of channels for knowledge transfer from the regional university system.

Table 2. Types of interactions with universities

Types of interactions	Percentage answering 'yes' in each type of interaction
Advanced services	
Consultancy work	21.8
Commissioning of research and development (R&D) projects to universities (contract research)	14.0
Use or rental of university facilities	8.1
Collaborative research	
Joint R&D projects	22.1
Joint ventures with universities and collaborative research centres	3.7
Human resource-based activities	
Training of university postgraduates and internships at the firm	27.5
Exchange of personnel	7.1
Training of firm workers by the university	15.2
Commercialization activities	
Patent exploitation	4.6
Participation in spin-offs and start-ups	3.9
Informal relationships	32.2
Other types of collaborative activities	1.9

Source: IESA (2009).

Table 3. Use of knowledge-intensive business services (KIBS)

Types of KIBS	Percentage answering 'yes' in each type of service
Technology KIBS	
Consulting for industrial development	25.5
Research and development (R&D) services	41
Information and communication technology (ICT) services	55
Electronic commerce and transactions	39
Professional KIBS	
Accreditations	51
Business planning and management	43
Marketing and commercial promotion	53
Accounting and financial services	83
Personnel recruitment	59
Legal services	41
Training services	77
Others	1.4

Source: IESA (2009).

Descriptive results show that the most common engagement with universities is through informal relations, meaning all types of engagement not supported by a formal contract or agreement (32% of the firms), followed by the training of postgraduates and internships at the firm (27%). Other interactions can be divided into three groups: consulting activities, joint research projects and training of firm workers by the university (each carried out by 15–25% of firms). Contract R&D projects, use of university facilities and personnel exchange were carried out by 5–15% of firms. Participation in spin-offs or start-ups, licensing and sale of patents, and joint ventures applies to fewer than 5% of the firms. Other types of collaborative activities, including participation in meetings, seminars, results diffusion, publications and so forth, were mentioned by fewer than 2% of firms.

The importance of training contracts and internships is worth noting, since the regional government provides easy access to this kind of training for university postgraduates. It is a common way of identifying future employees, potentially reducing the pitfalls of personnel selection. Consulting is also relevant, while the exploitation of intellectual property is clearly a minor activity even in those firms that could be considered as the most innovative in the region. Overall 421 firms (57%) reported no collaborations. Only 11 firms declared having only informal relations, suggesting that informal links are related to other types of channels.

The survey also included an indicator set for the utilization of services provided by firms reflecting both T-KIBS and P-KIBS sources (Table 3). T-KIBS consisted of consulting for industrial development, R&D services, ICT services, and electronic commerce and transactions. P-KIBS consisted of accreditations, business planning and management, marketing and commercial promotion, accounting and financial services, personnel recruitment, legal services, and training.

The questionnaire asked if a firm had used any of the above services provided by other firms in the last three years. The results show that more than 75% of the firms had used training and accounting and financial services. More than 50% had used ICT, technical accreditation, marketing and commercial promotion, and personal recruitment services. Finally, R&D services, electronic commerce, business planning and management, and legal services had been used by around 40% of firms. The least frequent service was consulting for industrial development, used by only 26% of firms. Descriptive statistics confirm that innovative firms of the region use most kinds of KIBS widely as a common input for their productive processes.

ECONOMETRIC ANALYSIS

Assumptions of the analysis

The goal of the analysis is to obtain a deeper understanding of the different industry–university interactions and their relation with KIBS. It is intended to identify which variables influence different forms of knowledge interactions and shape how regional firms draw knowledge from different sources, in particular universities and KIBS firms. For this purpose the variables targeted in the survey have been grouped to shed light on specific channels (Table 4).

Two groups of independent variables have been defined. The first group relates to the interaction of firms with universities, while the second group measures firms' utilization of KIBS. Regarding the linkages with universities, the dependent variables are count variables constructed from the types of interactions with universities indicated in Table 2. This dataset has been reduced to five core types of channels. The reduction was based on factor analysis of the same dataset carried out in previous descriptive studies, which show the aggregation of

Table 4. *Variables and descriptive statistics*

Variable	Explanation	Mean	SD	Minimum	Maximum
	Dependent variables on university–industry interactions				
UI	Total number of interactions between companies and universities	7.5	19.6	0	193
HR	Number of interactions based in training of university postgraduates and internships at the firm, exchange of personnel and training of firm workers by the universities	2.5	9.1	0	147
ADV	Number of consultancy exchanges, contracted research and development (R&D) projects, and uses or rental of university facilities	1.9	6.4	0	81
COOP	Number of collaborative R&D projects, joint ventures with universities and other types of collaborative activities	1.1	5.9	0	102
COM	Number of participations in spin-off and start-up company creation and industrial property rights exploitation	0.3	3.8	0	100
INF	Number of informal contacts	1.6	7.2	0	100
	Dependent variables on KIBS utilization				
UTKIBS	Number of 'new technology-based services' (T-KIBS) types the company uses[a]	1.6	1.23	0	4
UPKIBS	Number of 'traditional professional services' (P-KIBS) types the company uses[a]	4.0	1.87	0	7
	Independent variables: structural characteristics of the firm				
AGE	Years since the creation of the company	17.8	21.3	1	338
WRK	Number of workers in the company	55.8	238.3	1	3580
VOL	Dummy variable: 1 if the company has a annual turnover above €1 million	0.55	0.50	0	1
EXPORT	Dummy variable: 1 if the company exports to European Union countries or other international markets	0.30	0.46	0	1
AGRIC	Dummy: 1 if the company belongs to the agro-food, fishing and mining	0.07	0.25	0	1
IND	Dummy: 1 if the company belongs to manufacturing	0.30	0.46	0	1
CONST	Dummy: 1 if the company belongs to traditional services and construction	0.26	0.44	0	1
TKIBS[a]	Dummy: 1 if the company belongs to the T-KIBS sector	0.21	0.41	0	1
PKIBS[a]	Dummy: 1 if the company belongs to the P-KIBS sector	0.159	0.367	0	1
	Independent variables: absorptive capacity				
QUAL	Percentage of workers with higher education qualifications	35.0	36.3	0	100
INT_RD	Dummy: 1 if the company has an internal R&D department	0.62	0.49	0	1
INOV	Dummy: 1 if the company introduced innovation to the market in the reported period	0.58	0.49	0	1
IPR	Dummy: 1 if the company has registered industrial property rights such as patents or utility models	0.20	0.40	0	1
	Independent variables: proximity and location				
STP	Dummy: 1 if the company is located in a science and technology park	0.08	0.28	0	1
UNIV	Dummy: 1 if the company considers itself to be closely located to the university	0.72	0.45	0	1
MNE	Dummy: 1 if the company considers itself to be closely located to multinational enterprises and high-technology companies	0.36	0.48	0	1

Note: [a]Variables used as dependent variables in the models where they apply.

variables in groups reflecting a common variance in activities related to training and exchange of human resources, consultancy, collaborative research, and patents and creation of firms (Ramos-Vielba and Fernández-Esquinas, 2011). The variables were built by summing up the number of interactions declared in the given period. The study focuses on six dependent variables. The first variable (*UI*) represents all industry–university interactions counted. It is presented to understand, in general, the aspects that influence the intensity of interactions. The additional five dependent variables reflect different flows of knowledge transfer:

- *HR*: this group of variables reflects the numbers of human resource-based interactions. It includes training of postgraduates and internships, exchange of personnel with universities, and training of business workers by universities. These interactions can be considered as related to the provision of P-KIBS from the university side.
- *ADV*: this group of variables includes interactions based on knowledge-based advanced services. It includes technological assessments and consultancy, contracted R&D projects, or services regarding the utilization of university facilities. These interactions can be considered as similar to the provision of T-KIBS provided by specialized firms.
- *COOP*: this focuses on cooperative research. It is related to joint R&D projects, the development of collaborative initiatives, such as joint research centres, and other research collaborations supported by public R&D programmes.
- *COM*: this focuses on 'academic entrepreneurship' related to the commercialization of science. It

includes co-ownership and licensing of academic industrial property rights and the creation of new spin-offs.
- *INF*: this is based on the reported number of informal relations that are not based on formal or contractual relationships between the firm and a university group or body. Given than informal contacts are the most common type of interaction, usually associated with other types of relationships, for analytical purposes it is useful to consider it as an isolated dependent variable.

Regarding KIBS utilization, two variables have been constructed to reflect the use of both technological and professional KIBS. These variables were created from the question that indicates whether or not the firm in the sample has used a specific type of service, as indicated in Table 3.

- *UTKIBS* is a count variable of the types of services used by firms, including consulting for industrial development, R&D services, ICT services and electronic transactions, and commerce (the variable has a maximum value of 4 for firms that have used all the services).
- *UPKIBS* is a count variable including accreditations, business planning and management, marketing, accounting services, personnel recruitment, legal and training services (the variable has a maximum value of 6).

The independent variables reflect the main factors underlined in the background section. The first group is related to the structural characteristics of the firm. In addition to *firm age* and *number of employees*, dummy measures are used to differentiate firms with less or more than €1 million of total turnover and *orientation to international markets*, distinguishing the firms that export more of 50% of the sales to other countries. The time span used was the average in the last five years. Regarding the *sector of activity*, the analysis distinguishes between the following groups: agro-food, fishing and mining; manufacturing; T-KIBS; P-KIBS; and traditional services and construction. The T-KIBS group includes technology consultancy firms, providers of R&D services, firms in ICT and firms in the sample that include in their services a technology component (for instance, water recycling or aerospace services). The P-KIBS group includes traditional service firms such legal services, education, accounting, marketing, personnel related services and others.

The second group of variables reflects the absorptive capacity of firms, the percentage of *workers with higher education degrees*, a dummy measure for the existence of *internal R&D department*, and a dummy measure for firms that declared to have brought *product innovation to market* in the last five years. Finally, other variable related to absorptive capacity reflects whether the firm has registered any kind of patent or *industrial property rights*.

The third group of variables is related to proximity and characteristics of the territory. These variables do not measure directly the distance, but specific attributes of the space that were reported by the surveyed firms, including the location in a science and technology park, proximity to universities or other PROs, and proximity to multinationals and high-technology companies in the close environment. In the construction of these dummies the notion of proximity is closer to a relational concept, a social construct that restricts the individual understanding of distance, according to its individual characteristics, rather than an evaluation of proximity based on simpler measures of geographical distance (Torre and Rallet, 2005).[7]

The cross-correlation analysis (Table 5) suggests some interesting considerations in relation to the three kinds of connections under consideration: between firms and universities, between firms and KIBS, and between KIBS and universities.

Industry–university interactions are especially associated with the provision of advanced services and informal relations. Commercialization activities present the lowest correlation with the total number of interactions from the group of dependent variables analysed.

Regarding *KIBS utilization by regional firms*, it is found to be positively associated with all university–industry dependent variables, in particular with the total number of interactions and the use of advanced services. The utilization of both types of KIBS (T-KIBS and P-KIBS) by firms is highly correlated; companies that use one type of KIBS often use the other. The utilization of KIBS is also associated with the existence of an internal R&D department and the introduction to new-to-market innovations.

In terms of the *use of universities by KIBS firms*, even if not statistically significant, it can be observed that being a T-KIBS provider is always negatively correlated with the dependent variables except for human resources-based interactions. Being a P-KIBS firm, by contrast, is positively correlated with all the dependent variables except commercialization. KIBS firms, particularly T-KIBS, are highly associated with the use of qualified human resources. T-KIBS firms are likely to be located in a science and technology park. Firms that are KIBS providers do not correlate with the utilization of KIBS provided by other companies.

Interestingly, the correlation pattern for all kinds of relationship with universities is repeated for those with P-KIBS and T-KIBS firms. Some structural characteristics of the firm (mostly the turnover and the orientation to international market) and overall the absorptive capacities (qualifications of workers, existence of internal R&D, existence of innovation activities, existence of intellectual property rights (IPR)) are related to most kinds of university–industry relationships. By the same token, all these variables are also

Table 5. *Correlation*

	UI	*HR*	*ADV*	*COOP*	*COM*	*INF*	*AGE*	*WRK*	*VOL*	*EXPORT*	*AGRIC*	IND	*CONST*	*TKIBS*	*PKIBS*	*QUAL*	*INT_RD*	*INOV*	*IPR*	*UTKIBS*	*UPKIBS*	*STP*	*UNIV*	*MNE*
UI	1																							
HR	0.674**	1																						
ADV	0.692**	0.230**	1																					
COOP	0.513**	0.195**	0.233**	1																				
COM	0.288**	0.023	0.033	0.044	1																			
INF	0.685**	0.200**	0.493**	0.104**	0.165**	1																		
AGE	0.090*	0.086*	0.053	–0.012	0.071	0.061	1																	
WRK	0.126**	0.101**	0.104**	0.063	0.033	0.055	0.127**	1																
VOL	0.096**	0.110**	0.100**	–0.001	0.035	0.015	0.183**	0.180**	1															
EXPORT	0.230**	0.130**	0.223**	0.126**	0.086*	0.114**	0.142**	0.120**	0.231**	1														
AGRIC	0.091*	0.003	0.092*	0.024	0.162**	0.055	0.032	0.056	0.021	0.060	1													
IND	–0.015	0.016	–0.029	–0.034	–0.033	0.010	0.176**	–0.020	0.120**	0.183**	–0.175**	1												
CONST	–0.173**	–0.132**	–0.105**	–0.105**	–0.045	–0.101**	–0.044	–0.009	–0.042	–0.206**	–0.159**	–0.391**	1											
TKIBS	–0.033	0.003	–0.044	–0.020	–0.022	–0.026	–0.153**	–0.028	–0.136**	–0.050	–0.139**	–0.343**	–0.311**	1										
PKIBS	0.157**	0.085*	0.153**	0.104**	–0.003	0.100**	–0.078*	0.034	0.047	0.005	–0.112**	–0.275**	–0.249**	–0.191**	1									
QUAL	0.205**	0.113**	0.130**	0.148**	0.067	0.144**	–0.102**	–0.042	–0.083*	0.135**	–0.054	–0.123**	–0.209**	0.196**	0.227**	1								
INT_RD	0.177**	0.110**	0.167**	0.073*	0.048	0.109**	0.034	0.077*	0.059	0.260**	–0.016	0.012	–0.203**	0.169**	0.060	0.217**	1							
INOV	0.157**	0.104**	0.160**	0.108**	–0.018	0.075*	0.028	0.084*	0.117**	0.260**	–0.026	0.034	–0.147**	0.105**	0.026	0.175**	0.341**	1						
IPR	0.164**	0.039	0.204**	0.131**	0.010	0.103**	–0.009	0.079*	0.085*	0.292**	0.069	0.082*	–0.138**	–0.008	0.026	0.094*	0.205**	0.259**	1					
UTKIBS	0.183**	0.128**	0.174**	0.102**	0.022	0.087*	0.033	0.110**	0.116**	0.246**	–0.006	0.037	–0.171**	0.092*	0.059	0.179**	0.359**	0.368**	0.181**	1				
UPKIBS	0.225**	0.151**	0.186**	0.116**	0.073*	0.122**	0.106**	0.183**	0.236**	0.273**	–0.015	0.091*	–0.185**	0.000	0.108**	0.132**	0.332**	0.409**	0.244**	0.577**	1			
STP	0.220**	0.116**	0.138**	0.249**	0.137**	0.054	–0.071	0.106**	0.042	0.080*	–0.060	–0.090*	–0.145**	0.203**	0.095**	0.275**	0.163**	0.167**	0.094*	0.150**	0.153**	1		
UNIV	0.139**	0.105**	0.086*	0.075*	0.041	0.087*	0.038	0.060	0.064	0.131**	0.009	0.009	–0.170**	0.054	0.118**	0.230**	0.147**	0.145**	0.051	0.184**	0.175**	0.177**	1	
MNE	0.103**	0.046	0.104**	0.053	0.057	0.057	–0.020	0.037	–0.007	0.054	0.005	–0.046	–0.130**	0.113**	0.052	0.166**	0.128**	0.191**	0.068	0.163**	0.169**	0.217**	0.309**	1

Note: **Pearson's correlation is significant at 99%; and *Pearson's correlation is significant at 95% (two-tailed).

related to a greater use of P-KIBS and T-KIBS. This suggests that more innovative and dynamic firms draw from all kinds of sources, using a more open innovation strategy. For this regional environment, it can be assumed that KIBS are at least as important as universities for producing relevant knowledge for innovative firms.

Econometric estimation

The characteristics of the dependent variables selected for this study justify the utilization of a count data model approach in the econometric analysis.[8] This is a family of econometric techniques well established in innovation studies since the seminal study of HAUSMAN *et al.* (1984). The utilization of count data models in the study of innovation and industry–university interactions is common. A recent example can be found in D'ESTE and IAMMARINO (2010).

The characteristics of the data used here, including over-dispersion of the dependent variables, confirmed by the comparison of standard deviations and means, suggest the utilization of Negative Binomial estimation. The estimated likelihood ratios confirmed that a Negative Binomial is preferable to Poisson estimation for all the dependent variables of university–industry interactions. The utility of a zero-inflated version, because of the high proportion of zeroes in the dependent variables, was not confirmed with the realization of the Vuong test (VUONG, 1989). In this way, six Negative Binomial models were estimated. The explanatory capacity of the models can be verified by the log-likelihoods of the full models and the likelihood ratio (LR) Chi-square tests (for details, see Table A2 in Appendix A).

Econometric results for university–industry interactions

The econometric results for university–industry interactions are synthesized in Table 6. The regression coefficients can be interpreted as the expected difference in the logs of counts of the dependent variable with a unit change in the specified independent variable, given that other independent variables are held constant.

The total number of interactions with universities (*UI*) depends mainly on the absorptive capacity of the firm, as measured by the qualifications of workers and the existence of internal R&D departments. In fact, both variables are critical for the intensity of industry–university interactions. The structural characteristics of the company, such as age, size (turnover) and export activity, also influence positively the number of interactions. Companies from the manufacturing and construction sectors show strong negative coefficients and so appear less open to university interactions. T-KIBS companies similarly have a smaller propensity to interact with universities, suggesting that these companies have accumulated the capacities they need. The location in a science and technology park and proximity to universities have a positive effect on university–industry interactions.

Human resources (*HR*)-based interactions with universities follow a similar logic of *UI*. The main difference compared with total interactions is that the use of P-KIBS plays an important role in increasing the type of interactions. Having registered a patent or other IPR also has a negative impact in the number of HR interactions. The location in a science and technology park is not relevant in this type of interactions. *Participation in advanced services* (*ADV*) is mainly influenced by the qualification of employees and internal R&D capacity. Export intensity is also important. The location in science and technology parks and the utilization of T-KIBS also increases the number of advanced services-based interactions. Companies from the agriculture sector are particularly associated with the utilization of advanced services from universities, reflecting the importance of firms that work in the agro-food sector and the focus of university research. Regarding *cooperative research* (*COOP*), it is affected negatively if a company is a T-KIBS provider. Companies from construction and traditional sectors, including agro-food, are less likely to participate in cooperative activities with universities. The utilization of T-KIBS is associated with cooperation with universities. For science *commercialization activities* (*COM*), proximity to universities seems important. The registration of patents and other types of IPR also induces further commercialization activities with universities. The turnover of the companies gains relevance in this type of interaction. Being part of the KIBS sector or utilization of KIBS are not significant to this type of industry–university interactions.

Informal relations (*INF*) are positively affected by the age of the firm and its absorptive capacity, in terms of qualification of employees and existence of an internal R&D department. Companies that export are more likely to develop informal relations. Companies that use actively IPR protection are also more able to develop informality further. The utilization of P-KIBS increments the number of industry–university informal relations. Proximity does not have a statistically significant impact on informality.

Econometric models for KIBS utilization

Two additional models were estimated regarding KIBS utilization, focusing on T-KIBS and P-KIBS (Table 7). In this case the econometric evaluation suggested that a regular Poisson was superior to Negative Binomial and to a zero-inflated version for the estimation technique (confirmed in Table A2 in Appendix A).

Compared with university–industry interactions, fewer factors influence the use of KIBS (*UPKIBS* and *UTKIBS*) by innovative firms in the region. Firms' structural characteristics show no influence on propensity to use KIBS, with the exception of turnover. Bigger firms present greater propensity to use P-KIBS,

Table 6. Estimated models for industry–university interactions

		UI		*HR*		*ADV*		*COOP*		*COM*		*INF*	
		Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE	Coefficient	SE
Structural characteristics	*AGE*	0.009**	0.004	0.012**	0.006	0.004	0.006	0.001	0.004	0.012*	0.007	0.013**	0.006
	WRK	0.001	0.001	0.001	0.001	–0.000	0.001	0.001	0.001	0.000	0.000	0.001	0.001
	VOL	0.402**	0.190	0.749**	0.258	0.497	0.255	0.401*	0.236	0.960**	0.472	–0.377	0.288
	EXPORT	0.799***	0.205	0.440*	0.264	1.153***	0.283	0.731***	0.225	0.030	0.490	0.813***	0.300
	AGRIC	0.210	0.500	–0.606	0.596	1.687**	0.833	–0.305	0.613	1.460	1.897	0.288	0.856
	IND	–0.860**	0.412	–1.056**	0.465	–0.336	0.740	–1.487***	0.548	–1.054	190.057	–0.737	0.780
	CONST	–1.736***	0.422	–2.355***	0.506	–0.612	0.749	–2.781***	0.612	–4.312*	2.259	–1.071	0.777
	TKIBS	–1.185***	0.413	–125.509***	0.464	–0.727	0.743	–1.664***	0.564	–2.120	1.960	–0.715	0.779
	PKIBS	–0.225	0.404	–0.886*	0.457	0.523	0.754	–0.570	0.554	–1.270	1.970	0.354	0.770
Absorptive capacity	*QUAL*	0.017***	0.003	0.018***	0.004	0.014***	0.004	0.015***	0.003	0.029***	0.007	0.022***	0.004
	INT_RD	0.958***	0.213	1.036***	0.264	1.257***	0.325	0.792***	0.265	0.146	0.605	0.837**	0.334
	INOV	0.267	0.209	0.282	0.267	0.239	0.303	0.339	0.237	–0.072	0.484	0.189	0.315
	IPR	0.082	0.225	–0.551*	0.283	0.397	0.298	0.328	0.242	1.363***	0.509	0.666*	0.342
	UTKIBS	0.027	0.094	–0.044	0.120	0.296**	0.120	0.054	0.105	0.003	0.225	–0.099	0.143
	UPKIBS	0.235***	0.061	0.287***	0.080	0.120	0.081	0.144*	0.075	–0.101	0.145	0.286***	0.098
Proximity	*STP*	0.628**	0.316	0.247	0.409	0.776*	0.401	1.405***	0.314	1.247**	0.569	0.468	0.496
	UNIV	0.456**	0.223	0.609**	0.293	0.149	0.307	0.414	0.268	1.688**	0.674	0.241	0.354
	MNE	0.001	0.200	0.106	0.264	0.089	0.262	–0.336	0.229	–0.638	0.446	–0.020	0.316
	_CONS	–1.380***	0.503	–2.359***	0.638	–3.616***	0.848	–2.307***	0.674	–4.638**	2.112	–2.878***	0.863
	/LNALPHA	1.459	0.076	1.826	0.094	1.896	0.105	1.254	0.118	1.989	0.235	2.160	0.108
	ALPHA	4.302	0.328	6.207	0.580	6.665	0.699	3.506	0.415	7.308	17.145	8.673	0.934

Notes: ***Significant at 99%, **significant at 95% and *significant at 90%.
SE, Standard error.

Table 7. Estimated models for knowledge-intensive business services (KIBS) utilization

		UTKIBS		UPKIBS	
		Coefficient	SE	Coefficient	SE
Structural characteristics	*AGE*	–0.001	0.001	0.001	0.001
	WRK	–0.000	0.000	0.000	0.000
	VOL	–0.040	0.064	0.115***	0.040
	EXPORT	0.056	0.068	0.016	0.044
	AGRIC	0.157	0.277	–0.136	0.170
	IND	0.130	0.256	–0.061	0.156
	CONST	0.084	0.263	–0.130	0.160
	TKIBS	0.180	0.257	–0.138	0.157
	PKIBS	0.096	0.258	–0.034	0.158
Absorptive capacity	*QUAL*	0.001	0.001	0.000	0.001
	INT_RD	0.259***	0.074	0.086**	0.045
	INOV	0.197***	0.072	0.170***	0.044
	IPR	–0.054	0.072	0.070	0.046
	UTKIBS	–	–	0.156***	0.017
	UPKIBS	0.215***	0.020	–	–
Proximity	*STP*	–0.037	0.100	0.012	0.066
	UNIV	0.106	0.076	0.027	0.046
	MNE	0.026	0.064	0.039	0.041
	_CONS	–1.011***	0.282	0.919***	0.165

Notes: ***Significant at 99%, **significant at 95% and *significant at 90%.
SE, Standard error.

but not T-KIBS. The variables influencing the use of both types of services are mainly related to the absorptive capacity of the firm. In general, the higher is the absorptive capacity, measured by the presence of an R&D department and the previous introduction of product innovations, the greater is the use of both T-KIBS and P-KIBS. Nevertheless, it is important to notice that the qualification of employees does not influence the use of KIBS. Although the coefficient is not negative, and therefore not conclusive, this result suggests a different role of human resources, namely that qualification of workers is important for interacting with universities, but not so much for interacting with other service firms. In some conditions these services firms may substitute the availability of specialized human resources by university services. This is not surprising as many KIBS activities may have been carried out internally in firms in the past – they are to some extent an alternative to in-house capacity by definition. Having patents and other IPR does not influence the use of KIBS. The firms that are T-KIBS themselves use more P-KIBS, suggesting a circulation of knowledge between service providers, utilization of the other type of KIBS, internal R&D and innovative activities. Finally, another interesting issue is about the role of proximity in KIBS provision. Proximity was found to be important for certain types of university–industry links (*COOP* and *COM*) and less important in others (*HR* and *ADV*) but not for KIBS provision. Proximity to universities, to multinational enterprises and localization in science and technology parks does not seem relevant to increase KIBS utilization.

CONCLUSIONS

The contribution of KIBS to innovation and regional development is an area of considerable academic and policy interest. However, far too little attention has been paid to the use by firms of both KIBS and universities in peripheral regions. This is relevant given the role of advance knowledge services in enhancing the competitiveness of places. This study adopted a broad view of specialist knowledge provision and sought to remedy this gap by examining in detail the connection between firms and universities, between firms and KIBS, and between KIBS and universities in the region of Andalusia, Spain. It provided an empirical account of the uses that firms made of universities and KIBS firms, viewing both groups of actors as potentially important sources of innovation.

The results confirm the idea that universities are used as a form of KIBS in Andalusia. The most frequently used interactions between universities and regional firms are those related to advanced services and human resources, which can be considered as being related to T-KIBS and P-KIBS, respectively. Firms do need certain human resources for interacting with universities. It is possible that some firms will use KIBS as a first threshold for improving their capacities for capturing external knowledge. With the exception of the agro-food industry, few firms use universities for R&D collaboration or IPR commercialization, reflecting a regional industrial structure dominated by SMEs and service firms. Other confirmed assumptions are related to the use of KIBS firms by innovative regional firms. Innovative firms make intense use of KIBS, especially the complementary expertise of P-KIBS.

The use of P-KIBS and T-KIBS and the interaction with universities are shaped by some of the same factors, especially clients' absorptive capacities related to R&D and innovation, showing that the more innovative firms are, the more propensity they show to use all kinds of external sources of knowledge. Larger firms – measured by turnover – have also greater propensity to use both sources of knowledge. The findings suggest a degree of complementarity between certain forms of university–industry links and types of KIBS. Indeed, firms that use T-KIBS are, on the one hand, more likely to use advanced services from universities and, on the other hand, less likely to experience other types of interactions with universities. Firms that use P-KIBS tend to use some kinds of channels more, mostly human resources and informal ones.

This generally confirms that KIBS firms play an important role as knowledge intermediaries in more peripheral regions. In a sense, KIBS recombine and adapt scientific knowledge and instruments to more directly productive processes, or according to ASLESEN and ISAKEN (2010), they play a mediating role between analytic knowledge and a synthetic knowledge basis of their clients. Thus, both universities and KIBS play an important role in the chain of knowledge circulation. In addition, KIBS firms use other KIBS more frequently. T-KIBS and P-KIBS firms in turn tend to use universities less frequently than firms in other sectors, probably because they have their own expert capacities.

The study facilitates to distinguish effects of firms being KIBS providers and of being KIBS users. The first group showed negative or no influence on the relationships with universities. This means that KIBS themselves do not find special interest in interaction with regional universities, maybe because most of them already have the human resources and expertise they need and do not find strategic advantage in local universities. The second group has positive relationships only with selected types of university–industry interactions: firms that use P-KIBS have more relationships for training and exchanging human resources, while the firms that use T-KIBS obtain advances services from universities. This suggests again the existence of knowledge circulation and that, for some firms, there are complementarities between KIBS utilization and university interactions.

Finally, some evidence was found of the local sourcing of knowledge from universities, but little evidence that proximity is important in relation to KIBS utilization. There is no evidence that access to KIBS is regionally bounded. This may suggest that, given the paucity of KIBS in the region, firms may be more likely to use KIBS outside of the region. Given the limitations associated with the proximity measures used in this study, the way in which KIBS interact locally and the importance of the regional context needs to be further explored.

These results have important policy implications for peripheral regions. Access to knowledge-intensive services is important for innovation, regardless of whether it is sourced from KIBS firms or universities. It is therefore important to consider not only KIBS and universities in isolation but also the broader sources of knowledge and the complementarities in innovation systems. The results suggest that universities tend to complement rather than substitute other sources of specialist knowledge. One shortcoming of the analysis is that other relevant sources of knowledge, such as clients and suppliers, are not considered, so the relative importance of KIBS and universities vis-à-vis other sources cannot be compared.

While more innovative companies with higher absorptive capacities use external sources of knowledge, both from universities and KIBS firms, to a greater extent, the relatively low use of both KIBS and universities by certain sectors of the economy is a source for concern. Traditional manufacturing and certain service sectors are crucial for peripheral regions such as Andalusia, thus their use of advanced services should be encouraged. Therefore, another of the limits of the analysis is the impossibility to compare the utilization of KIBS in non-innovative firms. Presumably, non-innovative firms may also make use of KIBS, in particular P-KIBS.

Two main lessons can be drawn for peripheral regions. On the one hand, in peripheral regions knowledge transfer from universities needs to be considered in a broader sense and adapted to the capacities of firms in the territory. It should therefore go beyond IPR and collaborative research, which can be appropriated only by a small group of firms. Regional innovation policy should be oriented to upgrading skills and competences in order to increase the likelihood of collaboration for innovation. Collaboration is less likely to occur, and less likely to be effective, if the necessary internal competences are absent. On the other hand, the provision of advanced services by universities, even when they may compensate for the relative absence of KIBS firms, should be handled carefully. It might be better to provide policy support for local firms to access the best KIBS even if they are outside the region, rather than subsidise universities to provide poor services. Even if universities may play a key role as KIBS providers, this does not mean that this should always be encouraged. Universities may be able to offer routine technical advice more cheaply than commercial firms because of the subsidy inherent in their public funding, but this may have the effect of crowding-out the market for KIBS. A way forward may be to stimulate universities participation in KIBS entrepreneurship, for example by encouraging spinning-off and incubation of new firms from postgraduates. These new KIBS firms, able to apply technical knowledge to productive processes of other firms and incrementing the regional innovative capacity, may reduce the effects of the aforementioned crowding-out effect by having from the outset a strong relationship with the mother university.

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APPENDIX A

Table A1. *Characteristics of the firms in the sample*

		Frequency	%
Belongs to a corporate group	Yes	168	22.8
	No	567	76.9
	No answer	2	0.3
Number of workers	1–5	225	30.5
	6–10	162	22.0
	11–25	174	23.6
	26–50	73	9.9
	> 50	101	13.7
	No answer	2	0.3
	Mean	56	
	Standard deviation (SD)	239	
Firm age	Seven years and fewer	133	18.0
	More than seven years	599	81.3
	Do not know/no answer	5	0.7
	Mean	18	
	SD	21	
Activity sector (PITEC)	Agriculture, fishing and mining	46	6.2
	Manufacturing	3	32.0
	Technology knowledge-intensive business services (KIBS)		21.0
	Professional KIBS		14.0
	Construction industry and traditional services		27.0
Geographic environment	Science or technology park	61	8.3
	Industrial park	209	28.4
	Urban area	398	54.0
	Rural area	60	8.1
	Others	6	0.8
	Do not know/no answer	3	0.4
Research and development (R&D) department	Yes, in this location	157	21.3
	Yes, in a different location	28	3.8
	No	551	74.8
	No answer	1	0.1
Number of workers in the R&D department	< 5	102	55.1
	5–9	34	18.4
	10 or more	38	20.5
	Do not know/no answer	11	5.9
	Not applicable	552	
Total		737	

Note: PITEC, Panel for Potentially Innovative Firms in Spain.

Table A2. Observations and tests for the adequacy of the estimation process

Models	*UI*	*HR*	*ADV*	*COOP*	*COM*	*INF*	*UTKIBS*	*UPKIBS*
Pseudo-R^2	0.070	0.071	0.086	0.146	0.210	0.066	0.1229	0.089
Log-likelihood	−1537.161	−973.510	−822.086	−679.950	−215.666	−756.102	−1022.605	−1393.185
LR $Chi^2(18)$	232.20	148.89	154.65	232.63	114.68	107.50	283.84	272.79
Prob > Chi^2	0.000	0.000	0.000	0.000	0.000	0.000	0.000	0.000
Likelihood ratio test of alpha = 0	$Chibar^2(01) = 9010.54$ Prob ≥ $Chibar^2 = 0.000$	$Chibar^2(01) = 4095.50$ Prob ≥ $Chibar^2 = 0.000$	$Chibar^2(01) = 2837.89$ Prob ≥ $Chibar^2 = 0.000$	$Chibar^2(01) = 1159.05$ Prob ≥ $Chibar^2 = 0.000$	$Chibar^2(01) = 213.79$ Prob ≥ $Chibar^2 = 0.000$	$Chibar^2(01) = 3217.86$ Prob ≥ $Chibar^2 = 0.000$	$Chibar^2(01) = 0.00$ Prob ≥ $Chibar^2 = 1.000$	$Chibar^2(01) = 0.00$ Prob ≥ $Chibar^2 = 1.000$
Vuong test	$z = 0.08$ $Pr > z = 0.468$	$z = -0.00$ $Pr > z = 0.501$	$z = -0.00$ $Pr > z = 0.501$	$z = -0.08$ $Pr > z = 0.531$	$z = -0.00$ $Pr > z = 0.503$	$z = -0.00$ $Pr > z = 0.502$	$z = -0.01$ $Pr > z = 0.502$	$z = -0.01$ $Pr > z = 0.503$

Source: Authors' own elaboration.

NOTES

1. This is, of course, not a new idea. The importance of external sources of knowledge and particularly business advice for SME growth has long been a source of scholarly interest (e.g., ROBSON and BENNETT, 2000). The literature has also stressed the key role of consultancies in innovation, generally in the context of wider brokering organizations such as intermediaries (HOWELLS, 2006).
2. Nevertheless, for clarity the broad notion of KIBS rather than KISA is used, meaning that they are services for business that can be provided by a diversity of organizations such as firms, public centres or semi-public organizations. The term 'KIBS firms' was used to refer to private service businesses providing KIBS. In some regions, important knowledge services for firms come from research and technology organizations (RTOs) that formally are private, sometimes managed by firm associations, but they function with an important amount of public subsidies. For instance, see OECD (2011).
3. These linking mechanisms should, however, not be studied in isolation. Collaboration may entail the use of several channels simultaneously (LEVY *et al.*, 2009; RAMOS-VIELBA and FERNÁNDEZ-ESQUINAS, 2011).
4. In addition to firms characteristic and geographical location, to estimate the contributions of different forms of university–industry interactions it is important to take into account the characteristics and motivations of researchers. Recent contributions highlight that incentives to collaborate with industry are related to seniority, institutional expectations and rewards, the connection of the activity to the personal research programme of the researcher, and the economic importance of collaboration (for instance, see MINDRUTA, 2013). In this article this discussion is not addressed since the source covers only the firm side, although studies in the same region confirm the importance of team composition and orientation of researchers in the types of channels used (PINTO and FERNÁNDEZ-ESQUINAS, 2013).
5. The main public research institutes are owned by the Spanish National Research Council (CSIC), which is the main national research corporation of the country, the regional centre for agriculture research (IFAPA), and the foundation for health research (IAVANTE), which owns several laboratories attached to public hospitals. PROs account for 14% of human resources and 20% of the expenditure of the public R&D system.
6. Due to confidentiality reasons the registry of firms did not have information regarding the activity and characteristics of the firms, only address, size and persons of contact. The address was used to build the strata of geographical location. For generalization purposes, the process of fieldwork when substituting non-respondents was directed to obtain a sample with the same distribution of the original population, resulting in a difference of less than 3% for each stratum (a combination of province and size of location). Afterwards the comparison of firm size in the sample and the population resulted also in less than 3% for each size group, which suggests a good representativeness of the sample.
7. The authors have also built a geographical proximity measure based in a question about the most significant university–industry collaboration in the perspective of the firm. The results were not included because the answers reflected ambiguous effects concerning proximity because of two

types of concerns. On the one hand, some firms referred the universities with relations common and stable, but, on the other hand, several others preferred to signal the linkages with high-profile PROs.

8. The estimation follows the proposal of CAMERON and TRIVEDI (1998). The departure point is the possible utilization of the Poisson model, although this type of specification is often too restrictive for the data. Where there is over-dispersion of the dependent variable it is preferable to use a Negative Binomial model. Another problem that is common in the use of count data is the excessive number of zeroes. This situation implies that standard count models, Poisson or Negative Binomial, are less adequate than their zero-inflated versions.

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